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**Neck Muscle Fatigue with
Helmet-Mounted Systems**

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14. ABSTRACT Helmet-mounted systems (HMS) allow aircrew to perform more efficiently in poor conditions. Optics allow improved visibility, night vision, helmet-mounted displays, and targeting capability. The cost to use them in high performance aircraft is unknown. Test flights were made with pilots wearing HMS and neck muscles were evaluated. Objectives were to test the functionality of the helmet-mounted devices and to determine the impact on pilots using them during high G acceleration. Changes in neck muscle strength were identified along with EMG evidence of fatigue. When flights occurred on an almost daily basis over 4 days, the force imparted to the neck was reduced each day. After recovering for five days, the neck muscle force returned to approximately original values.					
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Neck Muscle Fatigue with Helmet-Mounted Systems

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Background



- **High incidence of in-flight neck pain**
- **"Acute need for guidance on the maximum mass distribution characteristics of head-mounted devices" – Advisory Group for Aeronautical Research and Development, 1990**
- **Entry of more women into fighters**

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Objectives



- **Primary Objective** – consolidate findings and define research scope to quantitatively determine risk of injury to include strains and fatigue as well as ligamentous and bone failure induced from added head-supported mass and offset center of gravity
- Formalized requirements from Army, Navy, and Air Force
- Benefits to: aviators, small fast boat operators, other vehicle-mounted occupants

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Goals

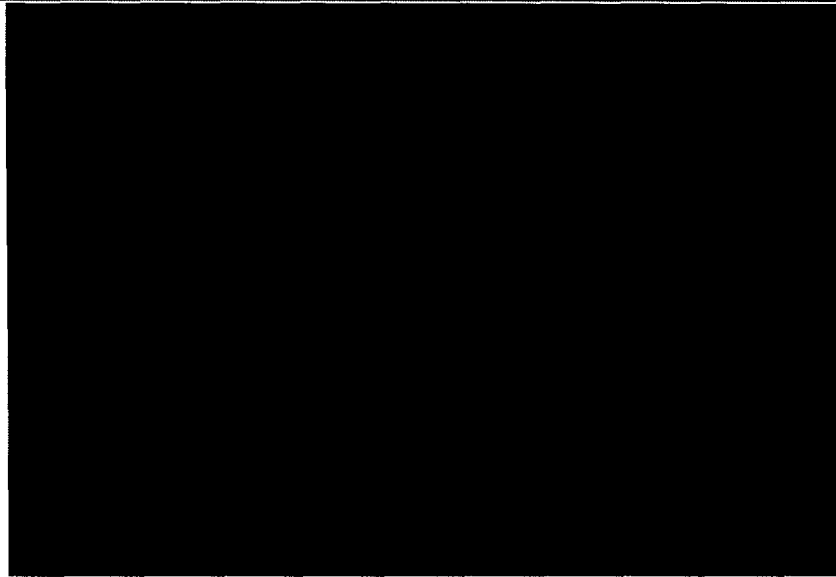


- Determine broad effects of helmet system characteristics and interactions on performance
- Develop understanding of criteria effects for designers of helmet systems
- **➡ Muscular ability to stabilize the neck ***
- Characterize neck muscle electrical activity
 - Any differences between males and females?

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Film Clip - Demo



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Implications



- **Expect continued high incidence of neck pain**
 - Working close to maximum strength capability
 - Females used 80% of maximum capability (males 29%)
- **Not able to move head with these weights**
 - Tasks requiring movement may be limited by HMDs
 - USAF operations often require G levels greater than the 6.5 G used in this research
- **Muscle strains**
- **Continued concerns for smaller individuals with small, less muscular necks**

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Developmental Flight Testing (DT)



- Gathered data to assess the potential for neck muscle fatigue
- Changes in neck strength and electromyography (EMG) from before and after test flights were evaluated for indications of neck muscle fatigue.
 - Interest in how well heavy helmets are tolerated by pilots
 - Effects on the human
 - Heavier helmets
 - No data for use as control condition
 - Changes in neck force and/or myoelectric activity may provide information to help refine helmet system design criteria.

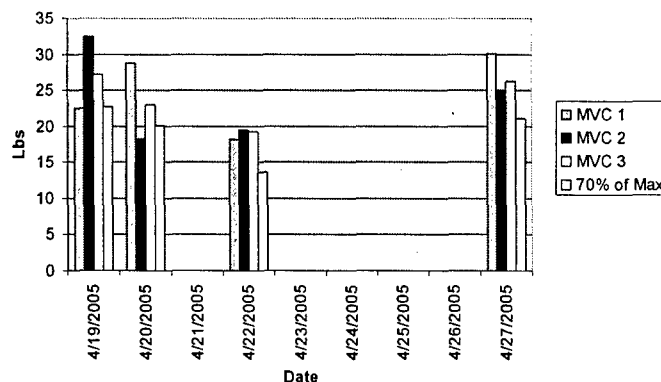
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Subject #1 Pre-Flight Strength



Subj 1 Summary Pre Fly



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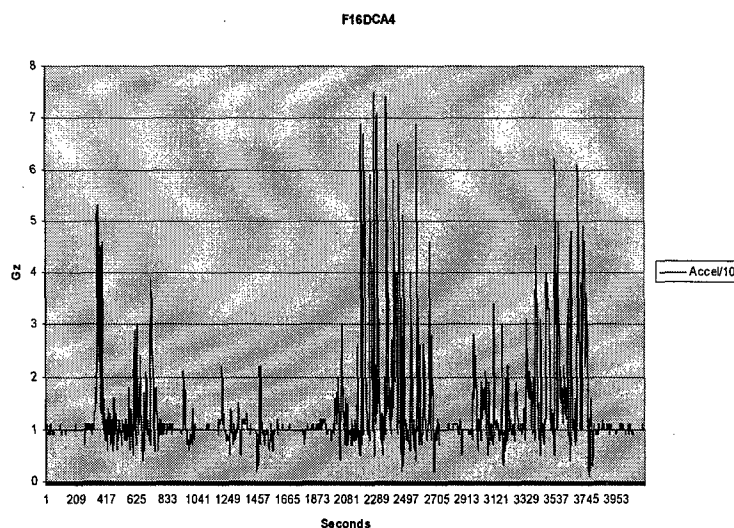
Diagram of Testing Procedure Sequence



- 1 – Warm-Up Exercises 3 minutes
- 2 – Maximal Voluntary Contractions (MVC)/Endurance – Neck Strength Test followed by “Bubble Task” 20 – 30 minutes
- 3 – High G centrifuge profile based on Nellis data (Mission 1) 90 minutes
- 4 – Maximal Voluntary Contractions (MVC)/Endurance – Neck Strength Test followed by “Bubble Task” 20 – 30 minutes
- Approximately 2 ½ hrs
- Lunch
- 5 – Static simulator with Re-fueling task Start with 15 minutes
- 6 – High G centrifuge profile based on Nellis data (Mission 2) 90 minutes
- 7 – Maximal Voluntary Contractions (MVC)/Endurance – Neck Strength Test followed by “Bubble Task” 20 – 30 minutes
- 8 – Static simulator with Landing task Start with 15 minutes
- 9 – Maximal Voluntary Contractions (MVC)/Endurance – Neck Strength Test followed by “Bubble Task” 20 – 30 minutes
- 10 – Questionnaire with follow-up Close to 6 hours 9



Representative G Profile Based on Operation Red Flag Data





Current Research



- **24 subjects with 3 helmet systems**
 - 12 males, 12 females
 - Active-duty military from sustained acceleration panel
 - Basic helmet for control
 - Heaviest helmet approaching 6 pounds
- **Provide guidance for acquisition process**
 - Program managers can guide designers on weight limits

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